Nuclear Sciences Program at Indiana University

Funding

NSF	Local Operations	FY2000:	$3.8M	FY2001:	$3.8M
NSF	Nuclear Proton Research	FY2000:	$2.7M	FY2001:	$2.7M
DOE	Nuclear Chemistry Research	FY2000	$405k	FY2001:	$538k
NSF	Accelerator Physics	FY2000	$ 95k	FY2001:	$ 95k
DOE	Accelerator Physics	FY2000	$180k	FY2001:	$185k

Staffing (FY01)

Permanent, Ph.D	21
Technician/Administrative	65
Postdocs	12
Graduate Students	17
Undergraduate Students	24

Users (FY01)	Total	PhD	/ Grad St	/ Other	DOE	/NSF	/Other US	/Foreign
	65	70%	20%	10%	25%	45%	10%	20%

I. Preface

The Indiana University Cyclotron Facility program is undergoing major changes as a result of the NSF decision to terminate support for local operations for nuclear physics research at the end of FY02. We have pursued aggressively new initiatives at other laboratories, which build on both our physics and technical expertise. The local cooler facility remains unsurpassed in its ability to provide full-polarized beam and target capability in a unique environment. There facilities also have been used extensively for a highly rated program in accelerator physics, which we hope will continue to find funding.

It is important to recognize that major construction projects such as the end-cap calorimeter for the STAR detector could not be undertaken at a university without either the hardware or technical manpower infrastructure of the scale now available at IUCF. This infrastructure also plays a significant role in attracting students into the discipline.

II. Current Research Program

a. Star – Spin
   - Construct Endcap Electro Magnetic Calorimeter for STAR detector at RHIC. (EEMC)
   - Perform first measurement of INTEGRAL for $\Delta G/G$ to accuracy of 0.2.

First determination of gluon contribution to nucleon spin.

- Project is funded with about $6.3M from NSF, which together with $0.7M matching funds from IU and $1 million per year for period FY00-02 from IUCF block grant gives T.P.C. in excess of $10 million.

b. Weak Interaction studies with cold neutrons
   - Parity violation in polarized neutron capture on protons at LANSCE. IUCF is providing gamma ray detectors and a LH2 target for this project.

c. Neutrino Oscillations
   - Installation of MiniBooNE experiment at FNAL. Definitive confirmation or rejection of the apparent neutrino oscillation signal seen at LANL.

d. Experiments on Cooler storage ring
   - Measurement of spin structure of 3-body forces from spin correlation in P + D elastic scattering and breakup.
   - Charge symmetry braking in $dd \rightarrow \alpha \pi^o$ due to up-down quark mass differences.
   - A determination of charged πNN coupling constant from absolute measurement of np scattering using a tagged neutron beam.
   - Threshold and near-threshold pion production.
   - Study of cluster formation in low-density liquid gas phase.

III. New Research Initiatives

a. EIC – The Electron Ion Collider

For the past 3 years we have been involved in promoting the science case for a next generation facility to study nucleon structure. Recently, we have been joined in this by BNL and MIT/Bates. Our own interest is to build a facility, which would allow us to determine what portion the projectile proton actually hit and how the nucleon responds to this. This means doing semi-inclusive or exclusive experiments requiring center of mass energies from 10-30 GeV and luminosities in excess of 10^{33} cm^{-2} s^{-1}.

We hope the long range planning group will endorse such a facility as an essential component of the world network of major accelerators and recommend research funding for accelerator and detector design studies in which we would participate.

b. Ultracold Neutron Facility Using the SNS.

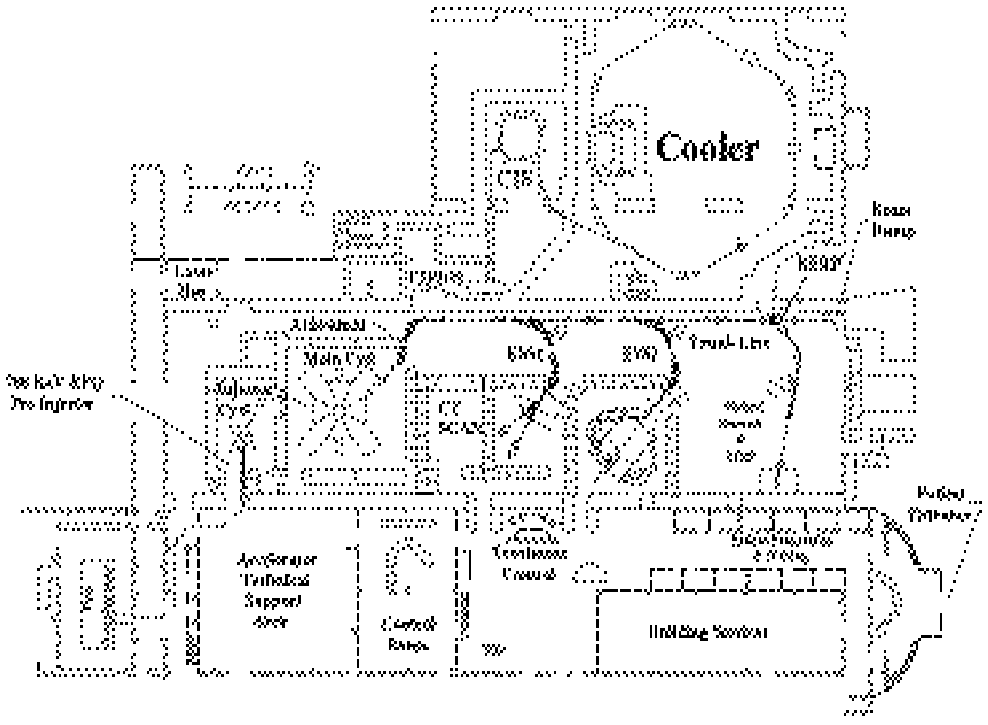
The high beam intensity and pulse structure of the SNS make it an ideal driver for producing ultracold neutrons for use in fundamental studies with neutrons. We are part of a collaboration, which proposes to develop such a facility; the goal would be to bring this on line about 2007.

IV. Facilities

The Indianan University Nuclear Physics group has a long and impressive history of the facilities developed for experimental research. The modern era includes the novel separated-sector cyclotron design, the first electron-cooled storage ring used for experiments, a series of state-of-the-art polarized ion sources, and several high-resolution spectrometers. Today, as we continue the transformation from a group with a local facility to an outside user group, we hope to be able to continue to make similar significant contributions to the infrastructure needs of the nuclear physics field.

During the past five years, the cyclotrons were replaced by a new accelerator system to inject beam into the electron-cooled storage ring (Cooler). The new system has an atomic beam source that can generate both polarized and unpolarized beams of negatively charged protons and deuterons. These beams pass through a pre-acceleration stage consisting of a radio-frequency quadrupole (RFQ) and drift tube linac (DTL) on their way to stripping injection into the Cooler Injector Synchrotron (CIS). There, beam is accumulated over many turns into a single intense bunch that is accelerated and passed along to the Cooler. The result is substantially (1-2 orders of magnitude) improved circulating current in the Cooler ring. The new construction also brings with it new and more reliable controls hardware. The completion of the Injector Synchrotron in 1998 was followed by the atomic beam source in 1999.

A plan of what the facility layout is shown below. This includes the new medical treatment facility now under construction.



All of this makes possible a new generation of experiments on the Cooler that involve either small cross sections (the search for the charge symmetry breaking reaction dd → α π^o), double scattering (measuring n+p elastic cross sections using tagged neutrons), or large volumes of data (measurements of the spin dependence of pd → ppn in the quest for signatures of three-body forces.

For future accelerator physics programs we are seeking funding to add a 150 MeV electron injector for the Cooler Synchrotron Ring. This would be used for studies of high energy electron cooling and optical stochastic cooling which would be of interest for EIC as well as many other projects.

V. Students and Postdocs

The fraction of graduate students at Indiana University who do their work in nuclear or accelerator science has remained pretty constant, i.e. we dropped by about 25% during the 90's in step with the overall decline in physics graduate students. This downward trend actually may have abated recently. The quality of the students remains good with many of our better students ending up in the lab.

The situation with postdocs appears to be much more acute. While we still are succeeding in getting good people the number of applicants is down very markedly from what it was just a few years ago.